1234330

PATENT SPECIFICATION

(11) 1234330

DRAWINGS ATTACHED

(21) Application No. 41069/69 (22) Filed 18 Aug. 1969

(45) Complete Specification published 3 June 1971

(51) International Classification G 01 c 3/14

(52) Index at acceptance

G2J 31D2B

G2A 15B3 15C1 15C2 15C3 15X

(72) Inventor EDWIN HERBERT LAND

(54) IMPROVEMENTS IN BINOCULAR RANGEFINDERS

(71) We, POLAROID CORPORATION, a corporation organised under the laws of the State of Delaware, United States of America, of 730 Main Street, Cambridge, Massachusetts, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to rangefinders, and more particularly to a binocular rangefinder for determining the range of an object in a scene upon which the sight lines of a user's eyes are converged.

Binocular rangefinders have been devised in the past which include optical means providing discrete left and right eye reticle images and range-determining means for adjusting the apparent separation on the left and right eye images while the eyes are focussed and converged on an object in a field of view such that a range determination of the object may be obtained with the range-determining means when the images are brought into apparent coincidence in the field of view. In such binocular rangefinders the left and right eye reticle images are interpreted by the user's nervous and visual sensory systems as a stereo pair of images of one world object. The natural reaction of the nervous system is to alter the ocular convergence angle, and thus the apparent separation of the images, in search of an angle at which the images appear to coincide. When apparent coincidence of the images is achieved, the system is satisfied that both eyes are converged on an object in the scene which has superimposed thereon the configuration of the reticle images and which is located at the vertex of the ocular convergence angle. The described condition wherein apparent coincidence of the reticle images is achieved is referred to hereinafter as the condition wherein the user has converged his eyes upon the reticle images. Examples of such rangefinders are shown in our earlier U.S. Patents Nos. 2,397,273; 2,397,274; 2,404,302; and 2,407,306. These patents broadly disclose a binocular rangefinder including optical means for providing similar left and right eye reticle images and range-determining means for altering the real and apparent displacement of the images. Utilizing the fact that the apparent displacement of the reticle images is a function of the convergence angle of the eyes, it is shown in these patents that the range-determining means may be used to bring the left and right eye reticle images into apparent coincidence such that the setting of the range-determining means at the condition of apparent coincidence of the images yields an indication of the range of the particular object upon which the user's eyes were fixed during the ranging operation.

Such rangefinders are satisfactory if the user is able during the ranging operation to fix his eyes constantly upon the world object to be ranged. However, it has been found to be difficult for the user of such rangefinders to resist the involutary urge to converge his eyes upon the reticle images rather than upon the world object. When this happens, of course, the convergence angle of the eyes no longer corresponds to the ranged object and the ranging ability of the device is affected.

A binocular rangefinder embodying the present invention is of the kind including optical means for imposing on a field of view common to both eyes a first reticle image observable exclusively by one eye and a second reticle image observable exclusively by the other eye in such a manner that the apparent separation between the first and second images is a function of the ocular convergence angle, and additionally includes means for making the images alternately visible and range-determining means coupled to the optical means for varying the apparent separation between the images so that for different convergence angles of the eyes corresponding to different ranging distances the apparent separation between the images may be reduced to zero to provide a range determination.

By alternating the visibility of the images,

[*Price 25p*]

the delay in the response of the nervous and ocular motive systems to sudden shifts in the viewed point is exploited. This response delay may be likened to the inertial effects of mass in physical systems, and may, in fact to a degree include such inertial effects due to the mass of the eyeballs and their motive structures. The rate at which the visibility intervals of the reticle images are alternated is preferably rendered sufficiently rapid that such inertial and response delay effects inhibit the tendency of the user to attempt to converge his eyes upon the reticle images.

The rangefinder may be arranged for use with a photographic viewfinder, the reticle images being shaped and arranged to delimit generally rectangular areas on the field of view presented by the viewfinder and serving, when brought into coincidence, to frame an exposable area of the field.

In order that the invention may be better understood, an example of apparatus embodying the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic front elevation view, partially sectioned, of a binocular rangefinder embodying the invention;

Figure 2 is a top view of the rangefinder illustrated in Figure 1;

Figure 3 is a side elevation view of the rangefinder shown in Figures 1 and 2;

Figure 4 is a pair of time vs. energization diagrams illustrating the phase relationship of the energization of lamps L_1 and L_2 in the rangefinder of Figures 1—3; and

Figures 5(a)—5(b) illustrate exemplary right and left eye reticle images which may be employed in the practice of the invention, the images shown in solid lines representing the apparent coincidence of the broken line right and left eye images as seen by a user of the rangefinder.

In the arrangement shown in Figures 1 to 3, a first optical means including a reticle 12 imposes a first reticle image upon the field of view of one eye and a second optical means 14 including a reticle 16 imposes a second reticle image upon the field of view presented to the other eye.

For convenience of description, it may be assumed that the first optical means 10 presents a reticle image to the user's left eye and that the second optical means 14 forms a reticle image to be viewed by the user's right eye. The optical means 10, 14 present reticle images visible on a field of view common to the left and right eyes. The left and right eye images are presented so as to be observable exclusively by the left and right eyes respectively, as will be described more fully hereinafter.

Numerous optical arrangements may be devised for rendering the reticle 12, 16 visible to the operator of the rangefinder. In the illustrated preferred arrangement, the first and second optical means may comprise, respectively, lamps L_1 and L_2 for illuminating reticles 12 and 16 through diffusing members 18 and 19. Short-focus lenses 20 and 21 may be provided for enabling the eye to focus upon the reticle 12. A transparent but partially reflective planar member 22 may be provided for imposing on the field of view of the user's eyes the images 26, 27 of reticles 12 and 16. The transparent member 22 may have a smooth semi-reflective surface 24 angled with respect to a world optical axis A—A and also with respect to an image optical axis B—B such that light transmitted from reticles 12, 16 along axis B—B is reflected into the user's eye along axis A—A.

The apparent separation of the reticle images 26, 27 is a function of the relative location of the reticle images 26, 27 in the left and right eye retinal images, which is, in turn, dependent upon the relative location of the reticle images 26, 27 with respect to the sight lines 28, 30 of the left and right eyes respectively. In Fig. 2 the reticle images 26, 27 are centered on the respective sight lines 28, 30 and thus would appear to coincide.

It is evident that the condition of apparent coincidence of the reticle images 26, 27 may be produced if the images 26, 27 are offset from the respective sight lines 28, 30 by a corresponding distance and in the same direction. Thus, the operation of the described rangefinder is not restricted as to where in the field of view the reticle images 26, 27 may be brought into apparent coincidence.

In the illustrated preferred embodiment, the condition of apparent coincidence of the reticle images 26, 27 for a given real separation "d" of the images 26, 27 on the transparent member 22 is associated with a unique ocular convergence angle "a". If the eyes are converged at any other angle, the reticle images 26, 27 will appear to separate laterally. Or, stated in another way, there is only one ocular convergence angle which corresponds to the distance from the rangefinder to a selected world object to be ranged. There is but one real separation distance "d" in the illustrated embodiment for a given ocular convergence angle at which the reticle images 26, 27 will appear to coincide. Thus, in a properly calibrated system, the real image separation distance "d" may be utilized as an indication of the range of the object upon which the sight lines 28, 30 of the user's eyes are converged.

Apparatus constructed in accordance with the invention may include range-determining means for adjusting the real separation distance "d" and thus the apparent separation of the reticle images 26, 27. In order to render the reticle images 26, 27 movable relative to each other, the positions of either or both of the images 26, 27 may be adjusted.

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This invention relates to rangefinders, and more particularly to a binocular rangefinder for determining the range of an object in a scene upon which the sight lines of a user's eyes are converged.

Binocular rangefinders have been devised in the past which include optical means providing discrete left and right eye reticle images and range-determining means for adjusting the apparent separation on the left and right eye images while the eyes are focussed and converged on an object in a field of view such that a range determination of the object may be obtained with the range-determining means when the images are brought into apparent coincidence in the field of view. In such binocular rangefinders the left and right eye reticle images are interpreted by the user's nervous and visual sensory systems as a stereo pair of images of one world object. The natural reaction of the nervous system is to alter the ocular convergence angle, and thus the apparent separation of the images, in search of an angle at which the images appear to coincide. When apparent coincidence of the images is achieved, the system is satisfied that both eyes are converged on an object in the scene which has superimposed thereon the configuration of the reticle images and which is located at the vertex of the ocular convergence angle. The described condition wherein apparent coincidence of the reticle images is achieved is referred to hereinafter as the condition wherein the user has converged his eyes upon the reticle images. Examples of such rangefinders are shown in our earlier U.S. Patents Nos. 2,397,273; 2,397,274; 2,404,302; and 2,407,306. These patents broadly disclose a binocular rangefinder including optical means for providing similar left and right eye reticle images and range-determining means for altering the real and apparent displacement of the images. Utilizing the fact that the apparent displacement of the reticle images is a function of the convergence angle of the eyes, it is shown in these patents that the range-determining means may be used to bring the left and right eye reticle images into apparent coincidence such that the setting of the range-determining means at the condition of apparent coincidence of the images yields an indication of the range of the particular object upon which the user's eyes were fixed during the ranging operation.

Such rangefinders are satisfactory if the user is able during the ranging operation to fix his eyes constantly upon the world object to be ranged. However, it has been found to be difficult for the user of such rangefinders to resist the involutary urge to converge his eyes upon the reticle images rather than upon the world object. When this happens, of course, the convergence angle of the eyes no longer corresponds to the ranged object and the ranging ability of the device is affected.

A binocular rangefinder embodying the present invention is of the kind including optical means for imposing on a field of view common to both eyes a first reticle image observable exclusively by one eye and a second reticle image observable exclusively by the other eye in such a manner that the apparent separation between the first and second images is a function of the ocular convergence angle, and additionally includes means for making the images alternately visible and range-determining means coupled to the optical means for varying the apparent separation between the images so that for different convergence angles of the eyes corresponding to different ranging distances the apparent separation between the images may be reduced to zero to provide a range determination.

By alternating the visibility of the images,

the delay in the response of the nervous and ocular motive systems to sudden shifts in the viewed point is exploited. This response delay may be likened to the inertial effects of mass in physical systems, and may, in fact to a degree include such inertial effects due to the mass of the eyeballs and their motive structures. The rate at which the visibility intervals of the reticle images are alternated is preferably rendered sufficiently rapid that such inertial and response delay effects inhibit the tendency of the user to attempt to converge his eyes upon the reticle images.

The rangefinder may be arranged for use with a photographic viewfinder, the reticle images being shaped and arranged to delimit generally rectangular areas on the field of view presented by the viewfinder and serving, when brought into coincidence, to frame an exposable area of the field.

In order that the invention may be better understood, an example of apparatus embodying the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic front elevation view, partially sectioned, of a binocular rangefinder embodying the invention;

Figure 2 is a top view of the rangefinder illustrated in Figure 1;

Figure 3 is a side elevation view of the rangefinder shown in Figures 1 and 2;

Figure 4 is a pair of time vs. energization diagrams illustrating the phase relationship of the energization of lamps L_1 and L_2 in the rangefinder of Figures 1—3; and

Figures 5(a)—5(b) illustrate exemplary right and left eye reticle images which may be employed in the practice of the invention, the images shown in solid lines representing the apparent coincidence of the broken line right and left eye images as seen by a user of the rangefinder.

In the arrangement shown in Figures 1 to 3, a first optical means including a reticle 12 imposes a first reticle image upon the field of view of one eye and a second optical means 14 including a reticle 16 imposes a second reticle image upon the field of view presented to the other eye.

For convenience of description, it may be assumed that the first optical means 10 presents a reticle image to the user's left eye and that the second optical means 14 forms a reticle image to be viewed by the user's right eye. The optical means 10, 14 present reticle images visible on a field of view common to the left and right eyes. The left and right eye images are presented so as to be observable exclusively by the left and right eyes respectively, as will be described more fully hereinafter.

Numerous optical arrangements may be devised for rendering the reticle 12, 16 visible to the operator of the rangefinder. In the illustrated preferred arrangement, the first and second optical means may comprise, respectively, lamps L_1 and L_2 for illuminating reticles 12 and 16 through diffusing members 18 and 19. Short-focus lenses 20 and 21 may be provided for enabling the eye to focus upon the reticle 12. A transparent but partially reflective planar member 22 may be provided for imposing on the field of view of the user's eyes the images 26, 27 of reticles 12 and 16. The transparent member 22 may have a smooth semi-reflective surface 24 angled with respect to a world optical axis A—A and also with respect to an image optical axis B—B such that light transmitted from reticles 12, 16 along axis B—B is reflected into the user's eye along axis A—A.

The apparent separation of the reticle images 26, 27 is a function of the relative location of the reticle images 26, 27 in the left and right eye retinal images, which is, in turn, dependent upon the relative location of the reticle images 26, 27 with respect to the sight lines 28, 30 of the left and right eyes respectively. In Fig. 2 the reticle images 26, 27 are centered on the respective sight lines 28, 30 and thus would appear to coincide.

It is evident that the condition of apparent coincidence of the reticle images 26, 27 may be produced if the images 26, 27 are offset from the respective sight lines 28, 30 by a corresponding distance and in the same direction. Thus, the operation of the described rangefinder is not restricted as to where in the field of view the reticle images 26, 27 may be brought into apparent coincidence.

In the illustrated preferred embodiment, the condition of apparent coincidence of the reticle images 26, 27 for a given real separation "d" of the images 26, 27 on the transparent member 22 is associated with a unique ocular convergence angle "a". If the eyes are converged at any other angle, the reticle images 26, 27 will appear to separate laterally. Or, stated in another way, there is only one ocular convergence angle which corresponds to the distance from the rangefinder to a selected world object to be ranged. There is but one real separation distance "d" in the illustrated embodiment for a given ocular convergence angle at which the reticle images 26, 27 will appear to coincide. Thus, in a properly calibrated system, the real image separation distance "d" may be utilized as an indication of the range of the object upon which the sight lines 28, 30 of the user's eyes are converged.

Apparatus constructed in accordance with the invention may include range-determining means for adjusting the real separation distance "d" and thus the apparent separation of the reticle images 26, 27. In order to render the reticle images 26, 27 movable relative to each other, the positions of either or both of the images 26, 27 may be adjusted.

In the illustrated embodiment the first optical means 10 is held in a fixed position relative to the mounting of the second optical means 14, and the second optical means 14 is rendered relatively movable.

For the purpose of supporting lamp L_1, diffusing member 18, reticle 12 and lens 20, in a fixed position and in order to optically segregate the first and second optical means 10, 14, a tubular housing 32 may be provided.

The second optical means 14 may be rendered adjustable by mounting lamp L_2, reticle 16, diffusing member 19 and eyepiece 21 in a tubular housing 34 supported for angular adjustment on a pin 36.

Range-determining means 37 are provided for translating adjustments in the separation between reticle images 16, 17 into useful range determinations. The range-determining means 37 may include adjustable means such as screw 38 for displacing the free end of the housing 34 against the bias of a leaf spring 40 acting up on a diametrically opposite point on the housing 34. The screw 38 may be provided with a radially oriented pointer 42 addressing a distance scale 44 carrying indicia 46.

As will be come more evident below, by properly calibrating the screw 38, range indications may be read directly off the distance scale 44. It should be understood, of course, that the rangefinder of the present invention may be incorporated in a photographic camera, in which case adjustments in the position of the reticle images 26, 27 would preferably be coordinated directly with focus adjustments of the objective lens means for the camera.

Many different arrangements may be employed for rendering the reticle images 26, 27 alternately visible in accordance with the present invention. In the illustrated embodiment lamps L_1 and L_2 are alternately energized from a power supply 48 through alternating switch means 50. The switch means 50 may take many forms. For example, it may comprise a manually rotatable switching member for alternately connecting lamps L_1 and L_2 through the power supply 48. The switching member may take the form of a flywheel set in motion before a ranging operation by a finger-actuated drive mechanism. In another arrangement the alternating switch means 50 may take the form of a bi-stable flip-flop switching circuit.

The diagram in Fig. 4 illustrates one phase relationship which the alternating switch means 50 may establish between the energization of lamp L_1 and L_2. The diagram shows the lamps L_1 and L_2 as being energized periodically and without a break between the termination of the energization of one lamp and the initiation of the energization of the other lamp. It should be understood, however, that it is the alternating nature of the visibility of reticle images 26, 27 which is important, and it is unnecessary that the visible intervals of the images 26, 27 be either periodic or without interruption.

In operation, the user need merely energize the lamps L_1 and L_2 through the alternating switch means 50 and look at the distant object through the transparent member 22. He thus converges the sight lines of his eyes upon the object in the scene to be ranged. Ordinarily, when initially viewing the world object to be ranged, the alternately visible reticle images 26, 27 appear to be separated, indicating that the range-determining means 37 is not properly set to accurately indicate the range of the viewed object. The user then manually adjusts the range-determining means, in the illustrated embodiment by rotating the screw 38, so that the reticle image 27 on member 22 is displaced with respect to reticle image 26. Accordingly, the apparent displacement between the reticle images 26, 27 is also altered. If the reticle images are identical, the user will have the impression of a single reticle image oscillating on the field of view between the extremes of the apparent displacement between the images.

The above-described inertial and response delay effects in the user's nervous and ocular systems have an inhibiting effect on an involuntary tendency of many individuals to attempt to converge his eyes upon the apparently oscillating reticle image. Preferably the rate at which the visibility intervals of the reticle images are alternated should be sufficiently great for the inertial impedance of the movement of the user's eyeballs to be a significant factor. In practice it has been found that a rate of alternation as low as two or less alternations per second is satisfactory.

The rangefinder of the present invention may be advantageously adapted for incorporation into or attachment upon a photographic camera. In such a photographic embodiment, the ranging operation and the location of the field of view may be effected simultaneously if the reticles 12, 16 are configured to define generally rectangular reticle images, as shown in Fig. 5(a) at 26′, 27′. The reticle images 26′, 27′ are preferably of a size appropriate for delimiting the average portion of the field of view to which the photosensitive material in the associated camera may be exposed.

In a photographic environment, as described above, the user will have the impression of a single bright rectangular shifting suddenly back and forth across his field of view. The user rotates the screw 38 in the appropriate direction until the reticle images 26′, 27′ coincide, that is, until the user has the impression that the reticle image has stopped oscillating on his field of view. The user then utilizes the apparently stationary rectangular

reticle image to frame the portion of the field which he wishes to record.

If the lamp energization phase relationship is as depicted in the Fig. 4 diagram wherein the initiation of the visibility interval of one lamp is coextensive in time with the termination of the immediately preceding visibility interval of the other lamp, the alternately visible reticle images give the appearance of a single, immovable image continuously visible in the user's field of view.

Assuming a proper calibation of the screw 38 with the distance scale 44, the range of the object upon which the eyes were converged during the ranging operation can be read directly off the pointer 42 on distance scale 44.

Fig. 5(b) illustrates reticle images which may be formed by an alternate reticle configuration. If reticles present the dissimilar reticle images shown in Fig. 5(b) are used, the user would be indicated that he has determined the proper range when he has apparently located the circular reticle image 26'' around the X-shaped image 27''.

Certain changes may be made in the above apparatus without departing from the scope of the invention herein involved. For example, it is within the capability of one skilled in the art to devise other structures for presenting a first reticle image observable exclusively by one eye and a second reticle image observable exclusively by the other eye and other means for causing the visibility of the first and second reticle images to occur alternately. It is possible to arrive at alternative arrangements for effecting relative movement of one or the other or both of the reticle images so as to effect a change in the apparent separation between the images. Other range-determining means may be devised. It is manifest that numerous reticle configurations may be devised other than those capable of producing the reticle images shown in Figs. 5(a)—5(b).

WHAT WE CLAIM IS:—

1. A binocular rangefinder comprising: optical means for imposing on a field of view common to both eyes a first reticle image observable exclusively by one eye and a second reticle image observable exclusively by the other eye in such a manner that the apparent separation between the first and second images is a function of the ocular convergence angle; means for making said images alternately visible; and range-determining means coupled to the optical means for varying the apparent separation between the images so that for different convergence angles of the eyes corresponding to different ranging distances the apparent separation between the images may be reduced to zero to provide a range determination.

2. A rangefinder as defined in claim 1 wherein the initiation of an interval of visibility of one of the images is substantially coextensive in time with the termination of the immediately preceding visibility interval of the other image.

3. A rangefinder as defined in claim 1 or claim 2 wherein the first and second reticle images appear similar in configuration so as to create the visual image impression of a single reticle image superimposed upon the field of view and oscillating between the extremes of the apparent image separation.

4. A rangefinder as defined in claim 3 wherein the first and second reticle images defined by the reticle means delimit generally rectangular areas, the images when brought into coincidence by the range-determining means serving to define an area on the field of view.

5. A rangefinder as defined in any one of claims 1 to 4 wherein the optical means includes, for forming the first and second images, separate optical systems each of which includes a reticle and at least one of which comprises, in combination, a light source for rendering the reticle visible, a short-focus lens, and a transparent optical member through which a scene may be viewed along a first optical axis, the optical member having a semi-reflective surface angled with respect to the first optical axis and to a second optical axis from the reticle to the member so as to impose an image of the reticle on the field of view.

6. A rangefinder as defined in claim 5 wherein the short-focus lens and its associated reticle are carried by pivotable mounting means, the range-determining means includes adjustable means operating on the mounting means for adjusting the orientation of the second optical axis to effect a real and apparent displacement of the respective reticle image.

7. A rangefinder as defined in claim 6, wherein the mounting means comprises a hollow cylindrical member and wherein the short-focus lens and its associated reticle and the light source are coaxially arranged in the member.

8. A rangefinder as defined in claim 5, 6 or 7 wherein each of the first and second optical systems includes an electrical lamp for rendering visible the respective first and second reticles, and wherein the means for making the images alternately visible com-

prises electrical switching means for effecting an alternate energization of the lamps.

9. A binocular rangefinder as defined in claim 1, substantially as herein described with reference to the accompanying drawings.

For the Applicants,
GILL, JENNINGS & EVERY,
Chartered Patent Agents,
51/52, Chancery Lane, London, W.C.2.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1971.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1234330 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

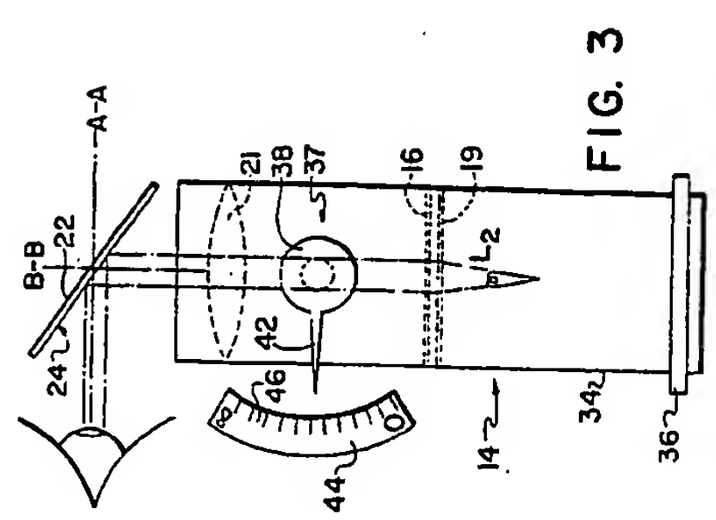

FIG. 3

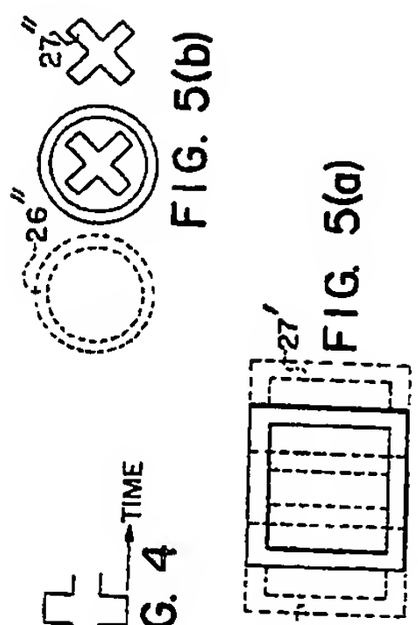

FIG. 5(b)

FIG. 5(a)

FIG. 4

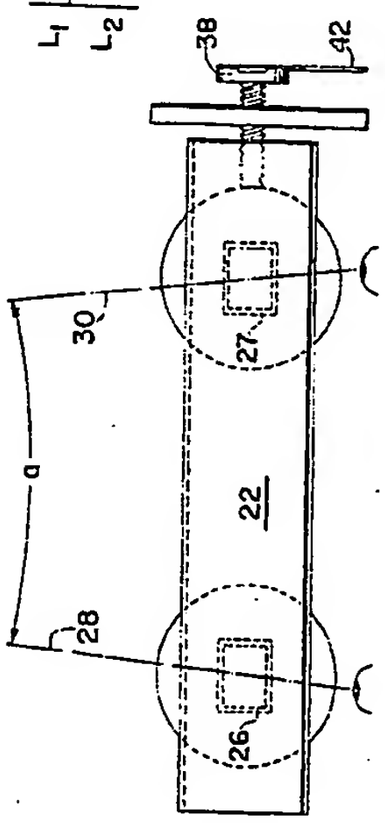

FIG. 2

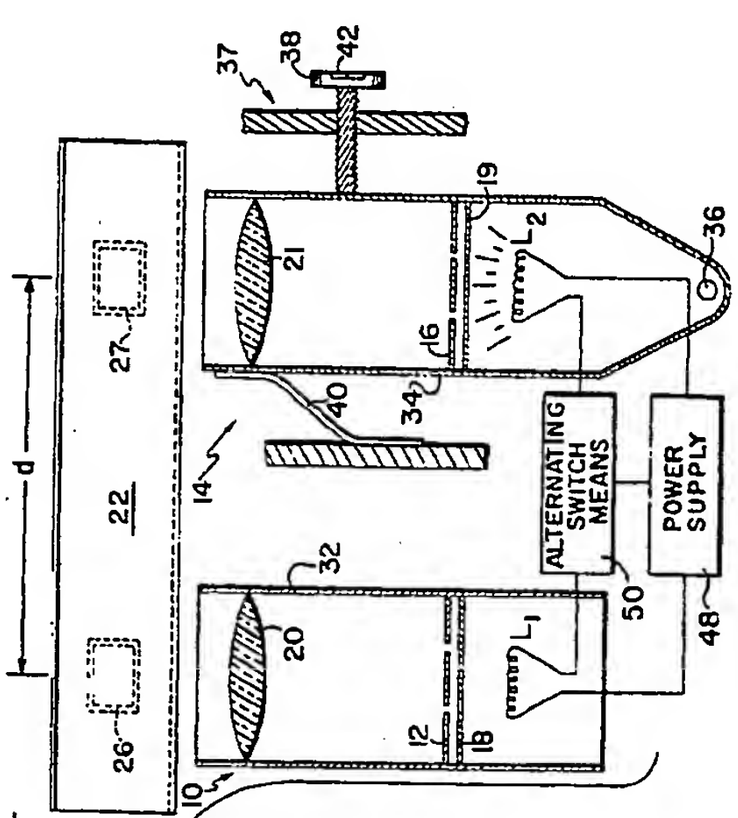

FIG. 1